

Three new *Cephalaeschna* species from central China with descriptions of the hitherto unknown sex of related species (Odonata: Aeshnidae)

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Three new *Cephalaeschna* species, *C. discolor* sp. nov. (holotype male; Shennongjia National Nature Reserve, Shennongjia City, Hubei province, China, 16 August 2012), *C. mattii* sp. nov. (holotype male; Lujiahe River, Zigui County, Hubei province, China, 18 September 2012) and *C. solitaria* sp. nov. (holotype male; Dalongtan in Shennongjia National Nature Reserve, Shennongjia City, Hubei province, China, 19 July 2012) are described, illustrated in color and compared with the known Chinese *Cephalaeschna*. All the holotypes are deposited in the Collection of Aquatic Animals, Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan City, Hubei Province, China. The hitherto unknown male of *C. obversa* and female of *C. patrorum* are also described and illustrated. Brief notes on biology of each species are also provided.

Keywords: Odonata; dragonfly; *Cephalaeschna*; new species; China

Introduction

Until recently, our knowledge of the genus *Cephalaeschna* was inadequate. They are among the rarest dragonflies in the Oriental region and a majority of species are known only from the types. All *Cephalaeschna* species are confined to running water habitats located in mountain ranges with dense forest, and some can live in extremely high mountains. Most species are on the wing late in the season. Their excellent flying ability allows them to easily elude the net of the collector.

Eight valid species have been recorded from mainland China in the works of Asahina (1981a, 1982), Wilson and Xu (2008) and Xu (2006). This suggests that *Cephalaeschna* is not as speciose as some related genera such as *Planaeschna*. However, in recent surveys from central and southwest China, several new species have been found, indicating that their species richness is greater than previously believed, and more undescribed *Cephalaeschna* must occur in mainland China. In this paper, three new species, collected from central China (Provinces Hubei, Sichuan and Guizhou) are described. Additional material from southwest China (Province Yunnan) will be discussed in a later publication.

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Asahina (1981a, 1981b, 1982) provided a diagnosis of the genus (separating *Cephalaeschna* from the closest related genera *Periaeschna* and *Gynacanthaeschna*), based on a series of specimens from throughout its range. Although he provided many figures when describing the new species, the structure of the terminal appendages and secondary genitalia were not well examined, especially the penis, which was not mentioned at all. After studying much fresh material from China, the structure of the appendages, especially the shape of the superior appendages, is here regarded as a good taxonomic character. The structure of the penis, with a pair of curved flagella in the end of the distal segment and a prominence near the proximal meatus of the stem segment, is also figured here to help separate some very similar species. Although in general the penis is rather simple and very similar between species it is of value in certain cases. These characters, combined with the color pattern which is mainly used in the early works, are applied together in this paper.

All the holotypes are deposited in the Collection of Aquatic Animals, Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan City, Hubei Province, China.

Abbreviations of abdominal maculation follow Walker (1912): S, abdominal segment; AD, anterodorsal; AL, anterolateral; MD, mediodorsal; PD, posterodorsal; and PL, posterolateral.

Descriptions of new species

Cephalaeschna discolor sp. nov. (Figures 1–2, 10a–d)

Material examined

Holotype: male, Mt Shennongjia (Shennongjia National Nature Reserve), 31°28'23" N, 110°23'29" E, altitude 1250 m, Shennongjia City, Hubei province, China, Haomiao Zhang leg., 16 August 2012 (time: 1925 h). *Paratype* female: same as holotype; *Paratype* 1 male: same locality and collector, 16 September 2012 (time: 1425 h); 2 males: same locality and collector, 8 August 2012 (time: 1930 h).

Etymology

The name *discolor* means “of different colors”, an adjective with identical masculine and feminine forms in the nominative. The new species possesses green eyes, black body, green and yellow stripes and russet colored legs, which agrees well with the name.

Diagnosis

A medium sized, brightly marked aeshnid of average build, separated from its closest congeners by details of body marking and structure of male appendages.

Holotype (male)

Head. Eyes dark green in living specimen (Figure 1a–c). Labium brownish yellow, with dense fine setae. Labrum yellow, the lower margin darkened in color (Figure 1c). Anteclypeus brownish yellow. Postclypeus greenish yellow. Frons about 1/2 width of head, fundamentally dark brown frontally (Figure 1c) and with a “T” mark dorsally (Figure 1b). Upper margin of frons medially protruding upwards. Occiput black, fringed with long setae at margin.

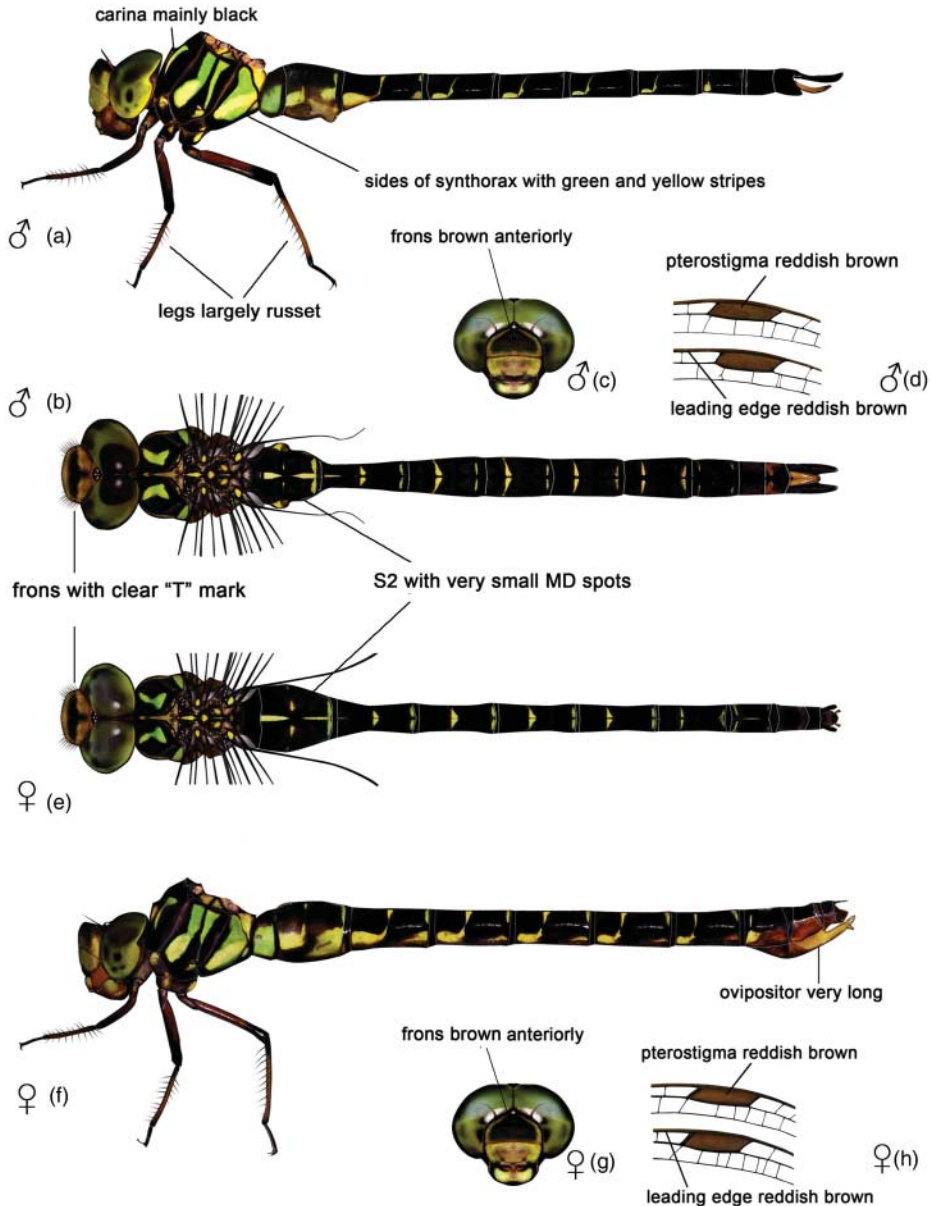


Figure 1. *Cephalaeschna discolor* sp. nov., holotype male (a–d) and paratype female (e–h): (a) body in lateral view; (b) body in dorsal view; (c) head in frontal view; (d) leading edge of wings and pterostigma; (e) body in dorsal view; (f) body in lateral view; (g) head in frontal view; (h) leading edge of wings and pterostigma.

Prothorax. Mainly yellow, median lobe with a pair of brown spots dorsally, hind lobe with a central brown band dorsally. Synthorax largely black with yellow and green stripes (Figure 1a): dorsal carina with small yellow spots; dorsal stripes on mesepisternum narrowed anteriorly and bent outwards, greenish yellow; mesepimeron with broad stripe, the upper half green and lower half yellow; metepisternum with elongated triangular stripe, not connecting with broad stripe on mesepimeron, green in color; metepimeron with a broad green stripe, its lower half with an oblique wavy yellow stripe. Legs multicolored (Figure 1a): coxae brown with yellow spots, femur with the upper 2/3 russet and lower 1/3 black, tibiae mainly brownish red, tarsi black, claws brownish yellow.

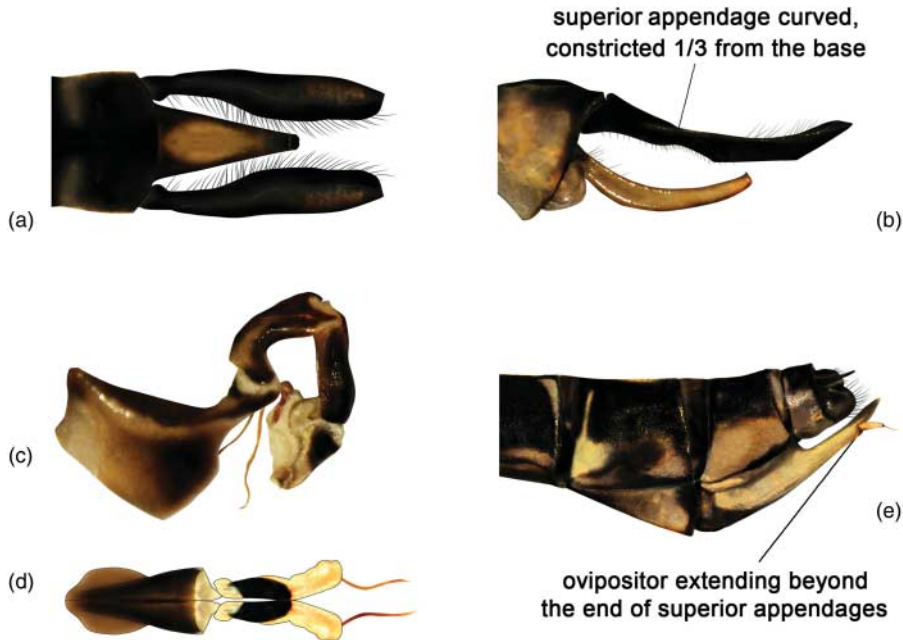


Figure 2. *Cephalaeschna discolor* sp. nov., holotype male (a–d) and paratype female (e): (a) appendages in dorsal view; (b) appendages in lateral view; (c) penis in lateral view; (d) penis in ventral view; (e) ovipositor.

Wings. Hyaline, base slightly tinted with smoky brown. Triangle 6-celled in forewings, 5- or 6-celled in hind wings, anal loop 6- or 9-celled, anal triangle 6- or 8-celled. Leading edge of wings and pterostigma reddish brown (Figure 1d): 3.0 mm in length. Pterostigma not well braced in both wings. Nodal index: 22: 26: 25: 21/24: 20: 18: 19.

Abdomen. Black with green and yellow markings (Figure 1a, b): S1 with large lateral spot; dorsal side of S2 with a longitudinal triangular AD spot, paired small MD and PD spots, and a slender and longitudinal central stripe, laterally S2 with large AL spots above auricle and irregular PL spots, auricle brown. S3 with linear AL spot, triangular MD spots which connect to the AL spot and small paired PD spots; S4–S7 with very small AL spot, triangular MD spots which extend downwards and connect to the AD spots; S8 with AL spots which connect to the linear MD spots, and paired very small PD spots; S9 and S10 mainly black with paired AD spots, more developed in S10.

Superior appendages. Black, curving upwards and constricted at 1/3 from base in lateral view (Figure 2b), in dorsal view expanded in apical 2/3 (Figure 2a), with an angled apex, not pointed; inferior appendage light brown, about 2/3 length of superior appendages in lateral view (Figure 2b), apex slightly bifid with very small paired prominences, darkened in color.

Penis. Mainly brown, stem with a slim and slightly bent prominence (Figure 2c), distal segment with a pair of semi-transparent slim flagella (Figure 2d).

Paratype (female)

Head and thorax. Very similar to the male (Figure 1e–g).

Wings hyaline, base slightly tinted with smoky brown. Triangle 5- or 6-celled in both forewings, 4- or 5-celled in hind wings, anal loop 6- or 9-celled, anal triangle 10- or 11-celled. Leading edge of wings and pterostigma reddish brown (Figure 1h), 3.0 mm in length. Nodal index: 18: 23: 21: 17/21: 17: 18: 21.

Abdomen. Black with yellow markings (Figure 1e, f): S1 with large lateral spots; dorsal side of S2 with a longitudinal triangular AD spot, paired linear MD spots which connect to the big rectangular AL spots and are interrupted in the middle, and paired linear PD spots connecting to the linear longitudinal central stripe. PL spots large and irregular in shape. S3–S8 similar to the holotype male, but with more developed yellow spots and paired PL spots. S8 with a dorsal central linear stripe. S9 and S10 mainly black. Ovipositor long, yellow, the apex extending beyond the end the superior appendages (Figure 2e).

Measurements (mm)

Holotype male: total length 67.0; abdomen (including anal appendages) 52.5; hind wing 44.5. Paratype female: total length 65.5; abdomen (including anal appendages) 51.5; hind wing 46.0. Paratype males: total length 65.5–66.5; abdomen (including anal appendages) 51.5–52.0; hind wing 45.0–50.0.

Variation in paratype male

The paratype male is rather aged, the color of pterostigma is darkened to brown, S8–S10 without dorsal stripes. The color of inferior appendages is slightly darkened.

Distribution

China (Hubei).

Notes on biology

Adults emerge from July onwards and all the specimens collected in the beginning of August were immature. Fully mature individuals appeared in mid August; in mid September they were rather aged, so the species flies from July to September. In August, the young adults only flew at dusk between 1920 h and 1940 h, when it was very difficult to see them clearly. The temperature was about 18–20°C. Usually they gathered in small groups to forage, circling at about 0.5 m above the open and narrow streams. However, in mid September, as the season changed, with the temperature only 10–12°C at dusk, no individuals were found after 1700 h. They could then only be seen on very sunny afternoons and were most active between 1330 h and 1530 h, when the temperature was 18–22°C. Territorial, courtship and oviposition behavior were not observed, but both sexes were found to fly along the semi-shady streams in September.

Discussion

Cephalaeschna discolor is very similar to *C. risi* Asahina, 1981 in appearance, both with black body, green and yellow thoracic stripes, green eyes and bi-colored legs. The broad green and yellow stripes across the sides of thorax are a good character to separate them from other congeners. Indeed these stripes are fundamentally green, and the yellow bands are obliquely included. The latter species has been well studied by Asahina (1981a) with figures. The holotype is from Fujian Province. One pair of specimens of *C. risi* (Figure 7e, f), collected from Zhejiang (Mt Fengyangshan), are used for comparison here. Except for many minor differences in color pattern, especially the largely red legs, the new species is also different from *C. risi* by the structure of appendages, with the inferior appendage 2/3 length of superior appendages, but slightly beyond

half of superior appendages in *C. risi*. The inferior appendage is bent upwards in lateral view in *C. discolor* but almost straight in *C. risi*. Detailed differences between the two taxa are discussed in Table 1. Photos of living types of *C. discolor* are shown in Figure 10a–d.

The genus *Cephalaeschna* has been characterized by having the brace vein to the pterostigma. However the pterostigma of this new species has a poorly braced or disrupted vein, as seen in the holotype male. Although the paratype male has a well-braced pterostigma, a majority of individuals have a poorly braced pterostigma. It seems this structure is very variable in this species.

***Cephalaeschna mattii* sp. nov.**
(Figures 3–4, 11a–d)

Material examined

Holotype: male, Lujiahe River, 36°56'49" N, 110°50'00" E, altitude 410 m, Zigui County, Yichang City, Hubei province, China, Haomiao Zhang leg., 18 September 2012 (time: 1430 h); *Paratype*: 1 male, same as holotype; 1 male, same locality and collector, 11 August 2012; 1 female, Mt Shennongjia, 31°28'23" N, 110°23'29" E, altitude 1250 m, Shennongjia City, Hubei province, China, Haomiao Zhang leg., 15 September 2012 (Time: 1505 h); 1 female, Mt Emeishan, Sichuan Province, China, Haomiao Zhang leg., 25 August 2010; 1 male, Mt Qingchengshan, Dujiangyan City, Sichuan Province, China, Haomiao Zhang leg., 30 August 2010.

Etymology

The new species is named after Dr. Matti Hämäläinen, in appreciation of his collaboration with the first author as well as his great help during the preparation of Haomiao Zhang's doctoral thesis. The specific epithet *mattii* is a noun in the genitive case.

Diagnosis

A medium sized, brightly marked aeshnid of average build, with S3 strongly constricted; separated from its closest congeners mainly by details of body marking and structure of male appendages.

Holotype (male)

Head. Eyes dark green in living specimen (Figure 3a–c). Labium brown, with dense fine setae. Labrum greenish yellow. Anteclypeus black. Postclypeus greenish yellow. Frons fundamentally greenish yellow, slightly narrower than 1/2 width of head, with a black spot anteriorly (Figure 3c) and a “T” mark dorsally (Figure 3b). Upper margin of frons medially protruding upwards with dense marginal setae. Occiput black, fringed with long setae at margin.

Prothorax. Mainly brown. Synthorax largely black with yellow and green stripes (Figure 3a): dorsal carina mainly black with very small yellow spots; dorsal stripes on mesepisternum tapered anteriorly and bent outwards, greenish yellow; mesepimeron with a broad stripe, narrowed in the middle, the upper half green and lower half yellow; metepisternum with elongated triangular stripe, not connecting with broad stripe on mesepimeron, green in color; metepimeron with broad green stripe, its lower half with a broad oblique yellow stripe. Legs black and yellow (Figure 3a): coxae brown with yellow spots, femur mainly yellow with the tips black, tibiae brown in forelegs, and mainly brownish yellow in middle and hind legs. Tarsi and claws brown.

Wings. Hyaline, base of wings slightly tinted with smoky brown. Triangle 5 or 6-celled in forewings, 6-celled in hind wings, anal loop 13-celled, anal triangle 5-celled. Leading edge of

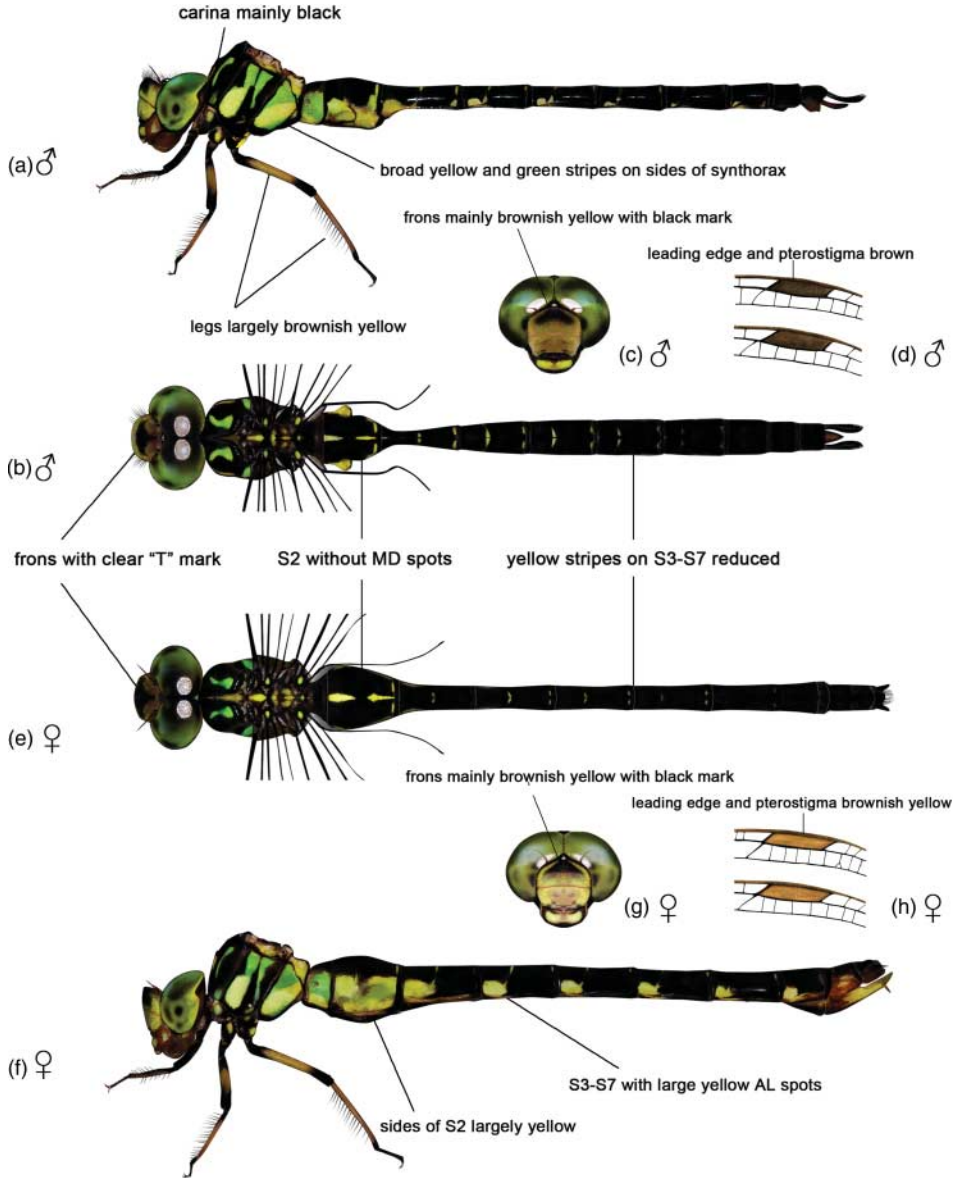


Figure 3. *Cephalaeschna mattii* sp. nov., holotype male (a–d) and paratype female (e–h): (a) body in lateral view; (b) body in dorsal view; (c) head in frontal view; (d) leading edge of wings and pterostigma; (e) body in dorsal view; (f) body in lateral view; (g) head in frontal view; (h) leading edge of wings and pterostigma.

both wings and pterostigma brown (Figure 3d), 3.0 mm in length. Nodal index: 21: 25: 24: 18/22: 18: 20: 20.

Abdomen. Black with yellow markings (Figure 3a, b): S1 with large lateral spot; dorsal side of S2 with a longitudinal triangular AD spot, paired linear PD spots, and a longitudinal central stripe, laterally S2 with large AL spots covering the auricle and irregular PL spots, connected to the linear PD spots. S3 strongly constricted (Figure 3b), with large AL spots, triangular MD spots not connecting with the AL spots, small paired PD spots and PL spots; S4–S7 with paired triangular MD spots which extend downwards but not connecting to the AD spots, and very small

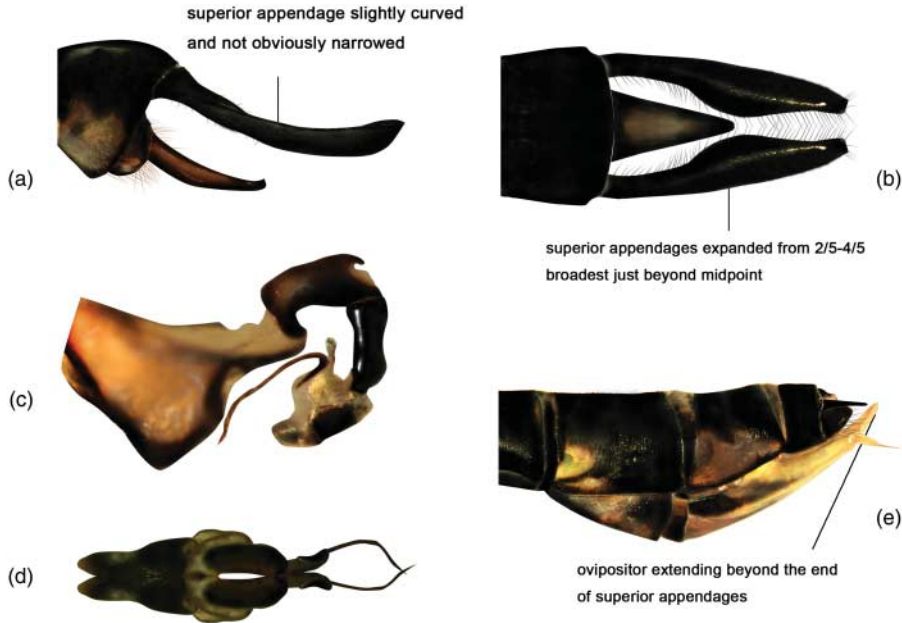


Figure 4. *Cephalaeschna mattii* sp. nov., holotype male (a–d) and paratype female (e): (a) appendages in lateral view; (b) appendages in dorsal view; (c) penis in lateral view; (d) penis in ventral view; (e) ovipositor.

paired PD spots; S8 with very small AL spots and PL spots; S9 and S10 black. S10 ventrally pale brown.

Superior appendages. Black, slightly bent upwards and not obviously narrowed in lateral view (Figure 4a), in dorsal view expanded inward to form a rounded bulge from apical 2/5–4/5, broadest a little beyond midpoint (Figure 4b). Inferior appendage pale brown, about 1/2 length of superior appendages (Figure 4a), tip not bifid in dorsal view.

Penis. Black and brownish yellow, the prominence on the stem slightly hooked (Figure 4c), the distal segment with a pair of slim flagella (Figure 4d).

Paratype (female)

Head and thorax. Very similar to the male (Figure 3e–g).

Wings. Hyaline, base of wings slightly tinted with smoky brown. Triangle 6- or 7-celled in forewings, 5- or 6-celled in hind wings, anal loop 11 or 13-celled, anal triangle 3- or 5-celled. Leading edge of wings and pterostigma brownish yellow (Figure 3h), 3.0 mm in length. Nodal index: 21: 25: 24: 18/22: 18: 20: 20.

Abdomen. Black with yellow markings (Figure 3e, f): S1 with large lateral spot; Dorsal side of S2 with a longitudinal triangular AD spot, paired linear PD spots, and a longitudinal central stripe, laterally S2 largely yellow. S3–S6 with comma-shaped large AL spots, paired MD spots and linear PD spots. S7 and S8 with AL spots. S9 and S10 mainly black. Superior appendages black, as long as S10. Ovipositor long, brownish yellow, the apex extending beyond the end of the superior appendages (Figure 4e).

Variation in paratype male

Two paratype males have paired dark brown AD spots on S10, with S10 ventrally darkened.

Table 1. Comparison of characters among *C. discolor*, *C. mattii* and *C. risi*.

Character	<i>C. discolor</i>	<i>C. mattii</i>	<i>C. risi</i>
Top of frons (both sexes)	With clear “T” mark	With clear “T” mark	Without “T” mark
Antefrons (both sexes)	Fundamentally dark brown	Fundamentally yellow with black stripes along the upper margin	Fundamentally yellow with black stripes along the upper margin
Dorsal stripe on mesepisternum (both sexes)	Conspicuous	Conspicuous	Very fine and reduced
Dorsal carina (both sexes)	Mainly black with small yellow spot	Mainly black with small yellow spot	Largely yellow
Stripe on metepisternum (both sexes)	Not connected to the broad stripe on mesepimeron	Not connected to the broad stripe on mesepimeron	Connected to the stripe on mesepimeron
Leading edge of wings and pterostigma (male)	Reddish brown	Dark brown	Reddish brown
Leading edge of wings and pterostigma (female)	Reddish brown	Brownish yellow	Brownish yellow
Median and hind legs (both sexes)	Femur with the upper 2/3 russet and lower 1/3 black, tibiae mainly brownish red	Femur mainly dull yellow with the tips black, tibiae mainly brownish yellow	Femur and tibiae mostly brownish yellow
S1 (male)	With large lateral spot	With large lateral spot	Without large lateral spot
S1 (female)	With large lateral spot	With large lateral spot	With large lateral spot
S2 (male)	MD spots small, AL spot not connected to PL spot	MD spots absent, AL spot connected to PL spot	MD spots clear; AL spot not connected to PL spot
S2 (female)	MD spots small, AL spot not connected to PL spot	MD spots absent, AL spot connected to PL spot	MD spots clear; AL spot connected to PL spot
Constriction of S3 (male)	Constricted	Strongly constricted	Strongly constricted
S3-7 (male)	AL connected to MD spots	AL not connected to MD spots	AL not connected to MD spots
S3-7 (female)	AL spot median sized	AL spot very large	AL spot gradually reduced to the tip
Superior appendages	Narrowed at 1/3 from base in lateral view; expanded in apical 2/3 in dorsal view; bent in lateral view.	Not obviously narrowed in lateral view; expanded in apical 2/5–4/5, especially just beyond midpoint in dorsal view; bent in lateral view.	Slightly narrowed 1/3 from base in lateral view; expanded in apical 2/3 in dorsal view; almost straight.
Inferior appendage	About 2/3 length of superior appendages	About 1/2 length of superior appendages	About 1/2 length of superior appendages

Measurements (mm)

Holotype male: total length 69.0; abdomen (including anal appendages) 54.5; hind wing 46.0.

Paratype female: total length 69.0; abdomen (including anal appendages) 54.5; hind wing 48.5.

Paratype male: total length 68.0–69.0; abdomen (including anal appendages) 53.0–54.5; hind wing 46.0–46.5.

Distribution

China (Hubei and Sichuan).

Notes on biology

The behavior of this new species is similar to that of *C. discolor*, and the two were found syntopically in the type locality of *C. discolor*, a stream located in Shennongjia National Nature Reserve over 1000 m altitude. *C. mattii* can be also found in some lower streams, and the elevation of

the type locality, the Lujiahe River, is only about 400 m. Some individuals were found to rest in the dense forest near a narrow and shallow stream on very hot afternoons. They hung from slim branches about 2–3 m above water. In August, the adults became active much later in the afternoon, and foraged until dusk. In mid September, aged individuals were very active in sunny afternoons, and usually after 1200 h females appeared. Males were active from 1400 h; they flew along the stream and sometimes went into the dense forest. Females oviposited on mossy rocks in the open stream or less than 0.5 m from the shore. Another *Cephalaeschna* co-occurring in the type locality is *C. klotsi*.

Discussion

The new species is close related to *C. risi* and *C. discolor* described above. The color of the pterostigma is clearly different between the sexes. According to the structure of superior appendages, *C. mattii* differs from *C. discolor* and *C. risi* by the strongly inwardly expanded bulge near to the middle in dorsal view (Figure 4b). The inferior appendage is about 1/2 the length of the superior appendages, a condition which is closer to *C. risi*. From the shape of abdomen in dorsal view, *C. mattii* is closer to *C. risi*, and has a more strongly constricted S3 than *C. discolor*. More detailed comparisons of the three species are given in Table 1 and photos of both sexes of living *C. mattii* are shown in Figure 11a–d.

Xu (2006) described a new species, *Cephalaeschna shaowuensis* from Fujian, based on a single female holotype. It can be distinguished from the females of *C. discolor* and *C. mattii* by many differences in the body maculation: (1) very fine and small dorsal stripes on mesepisternum; (2) stripe on metepisternum connecting with the broad stripe on mesepimeron; (3) S1 with a dorsal “T” mark; (4) abdomen with dorsal spots only on S2. A male of *C. shaowuensis* would be useful to compare it with other congeners.

Cephalaeschna solitaria sp. nov.

(Figures 5a–d, 6, 10e, f)

Material examined

Holotype: male, Dalongtan in Mt Shennongjia (Shennongjia National Nature Reserve), 31°29'30" N, 110°18'30" E, altitude 2300 m, Shennongjia City, Hubei province, China, Haomiao Zhang leg., 19 July 2012 (time: 1330 h); **Paratype:** 1 male, Shennongyuan in Mt Shennongjia, 31°28'16" N, 110°17'51" E, altitude 2300 m, Shennongjia City, Hubei province, China, Haomiao Zhang leg., 19 July 2012 (time: 1420 h).

Etymology

The Latin epithet *solitaria* means “lonely” or “solitary”. This new species was found in very high montane streams (2300 m), which is a rare situation in central China and it is the only dragonfly flying in the main protected area of the Shennongjia National Nature Reserve, Hubei.

Diagnosis

A small–medium sized, brightly marked aeshnid of average build, separated from its closest congeners by details of body marking and structure of male appendages.

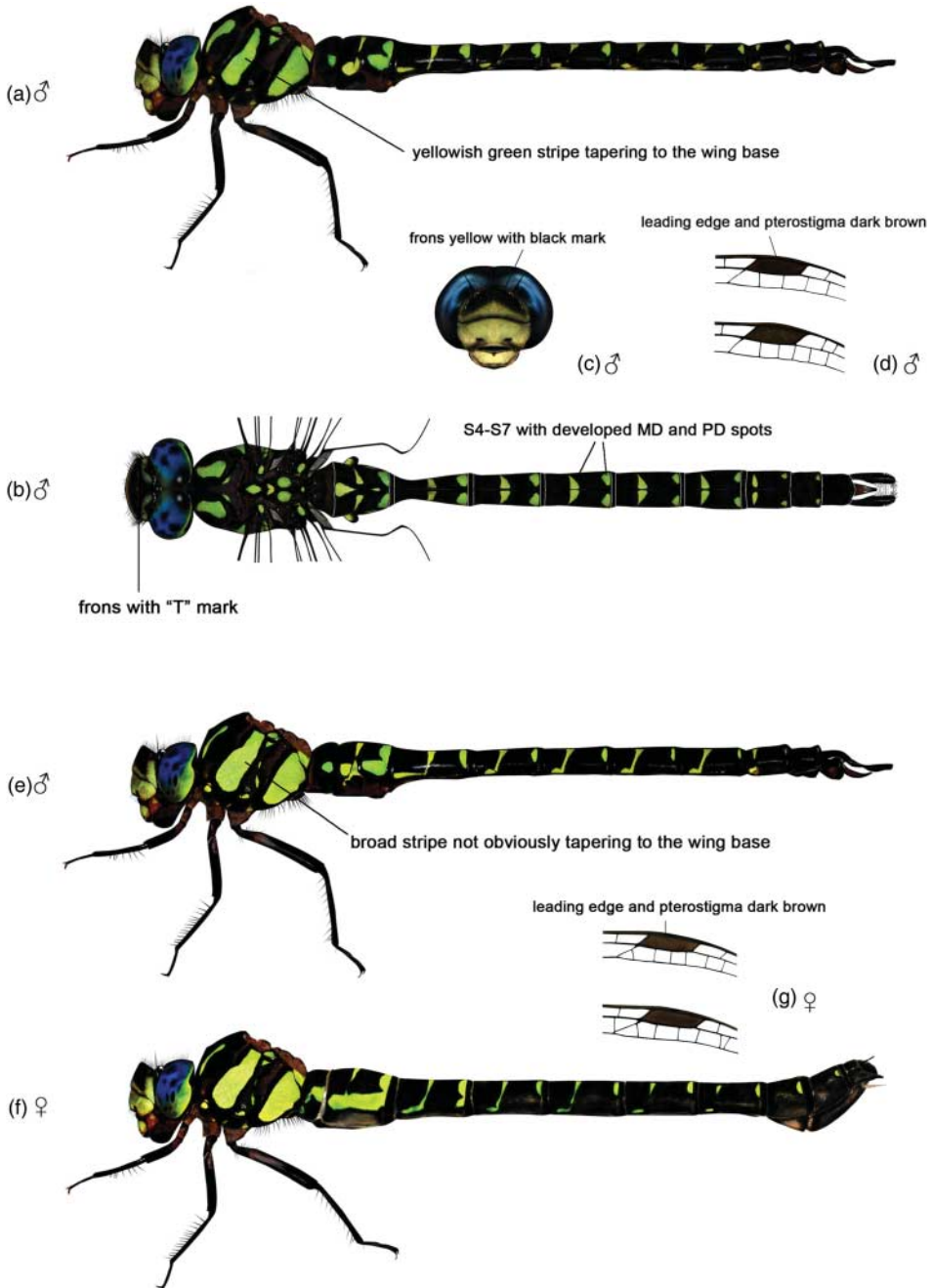


Figure 5. *Cephalaeschna solitaria* sp. nov., holotype male (a–d) and *C. patrorum* (male: e; female: f–g): (a) body in lateral view; (b) body in dorsal view; (c) head in frontal view; (d) leading edge of wings and pterostigma; (e–f) body in lateral view; (g) leading edge of wings and pterostigma.

Holotype (male)

Head. Eyes dark blue in living specimen (Figure 5a–c). Labium brown. Labrum greenish yellow with the lower margin pale brown (Figure 5c). Anteclypeus dark brown. Postclypeus greenish

yellow with the lower margin brown and a pair of black depressions. Frons fundamentally greenish yellow, about 2/3 width of head, with a large brown spot, an inverted “V” mark in frontal view (Figure 5c) and a “T” mark dorsally (Figure 5b). Upper margin of frons medially protruding upwards, with dense marginal setae. Occiput black, fringed with long setae at margin.

Prothorax. Mainly brown. Synthorax black with greenish yellow stripes (Figure 5a): dorsal carina entirely black; dorsal stripes on mesepisternum somewhat tapered anteriorly and bent outwards; mesepimeron with broad stripe, tapering to the wing base (Figure 5a); metepisternum with small inverted triangular shaped spot near the upper margin; metepimeron with broad stripe. Legs mainly dark brown (Figure 5a): coxae brown; femur mainly black with the base reddish brown; tibiae, tarsi, and claws mainly black.

Wings. Hyaline. Triangle 5-celled in forewings, 4-celled in hind wings, anal loop 9-celled, anal triangle 3-celled. Leading edge of both wings and pterostigma dark brown (Figure 5d), 2.5 mm in length. Nodal index: 18: 21: 23: 17/16: 14: 17: 16.

Abdomen. Black with yellow markings (Figure 5a, b): S1 with small lateral spots; S2 with triangular AD spot, paired triangular MD spots and paired semicircular PD spots. Laterally S2 with large AL spots above auricle and irregular PL spots which connect with the PD spots, auricle brown. S3–S8 with small AL spots and paired triangular MD spots which are expanded laterally, not connecting with the linear AL spots; S3–S9 with paired PD spots, more developed in S3–S5. S10 with a pair of very small rounded MD spots.

Superior appendages. Dark brown. In lateral view, curved slightly upwards, narrowed at mid-point (Figure 6a); in dorsal view, expanded in apical 3/4, with rounded apex (Figure 6b). Inferior appendage reddish brown, apex slightly bifid, 3/5 length of superior appendages (Figure 6a).

Penis. Mainly dark brown, stem with a robust prominence, not strongly hooked (Figure 6c). Distal segment with a pair of curved flagella (Figure 6d).

Female unknown.

Measurements (mm)

Holotype male: total length 66.5; abdomen (including anal appendages) 51.5; hind wing 42.5. Paratype male: total length 66.5; abdomen (including anal appendages) 51.5; hind wing 43.0.

Variation in paratype male

In the paratype male, S9 with paired PD spots, very small, S10 entirely black. Triangle 5-celled in hind wings, anal loop 10-celled.

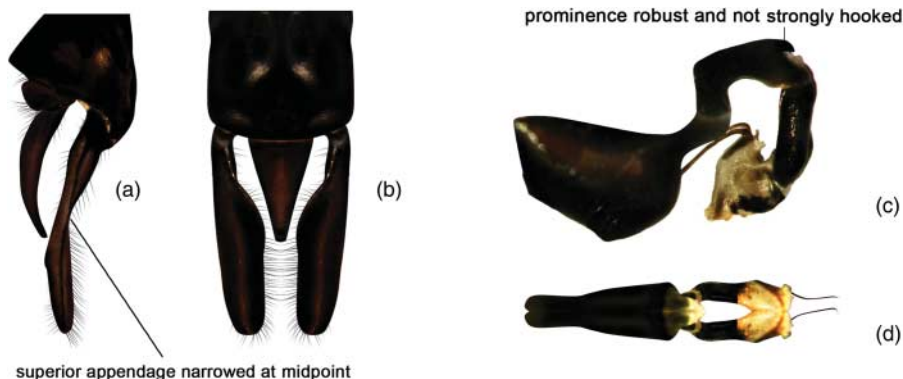


Figure 6. *Cephalaeschna solitaria* sp. nov., holotype male: (a) appendages in lateral view; (b) appendages in dorsal view; (c) penis in lateral view; (d) penis in ventral view.

Distribution

China (Hubei).

Notes on biology

Only two males of the species were collected at the end of July, and a female was also observed to oviposit in a very shady stream in the same day (unable to collect), it laid the eggs on a tree branch, about 0.8 m above the water. All the individuals were found to be active between 1300 h and 1500 h, when the temperature was about 20–22°C. Males even flew in the rain and held territory hovering about 30 cm above the water surface. Larvae live in very cold water and the temperature is only 10°C even in the hottest summer weather.

Discussion

Cephalaeschna solitaria is very closely related to *C. patrorum*, known from central and northern China, but different from the latter species in both body maculation and the structure of the appendages and penis. *C. solitaria* possesses more developed abdominal stripes but less developed thoracic maculation. Viewed laterally the superior appendages are narrowed at the midpoint in *C. solitaria* but at 2/5 from base in *C. patrorum* (Figure 9b). The stem of the penis possesses a robust and less hooked prominence above the proximal meatus in *C. solitaria*, but a more slender and strongly hooked process in *C. patrorum* (Figure 9c). More detailed differences are shown in Table 2, a male of *C. patrorum* from Beijing is illustrated in Figures 5e, 9a–d, and photos of the living holotype *Cephalaeschna solitaria* are shown in Figure 10e, f.

First description of the male *Cephalaeschna obversa* Needham, 1930

(Figures 7a–d, 8, 11e, f)

Diagnosis

A small–medium sized, brightly marked aeshnid of average build, separated from its closest congeners by details of body marking and structure of male appendages.

Material examined

One male, Mt Shennongjia (Shennongjia National Nature Reserve), Shennongjia City, Hubei province, China, Haomiao Zhang leg., 15 September 2012 (time: 1445 h), 1200 m; 1 male, 1 female, Xiangzhigou, Guiyang city, Guizhou province, China, Haomiao Zhang leg., 1 September 2011 (time: 1905 h).

Male

Head. Eyes dark green in living specimen (Figure 7a–c). Labium pale brown. Labrum dark brown with the upper margin black and a pair of yellow spots (Figure 7c). Anteclypeus dark brown. Postclypeus greenish yellow. Frons fundamentally greenish yellow, about 3/4 width of head, with a large black spot mark in frontal view (Figure 7c) and largely black in dorsal view (Figure 7b). Upper margin of frons medially protruding upwards, with dense marginal setae. Occiput black, fringed with long setae at margin.

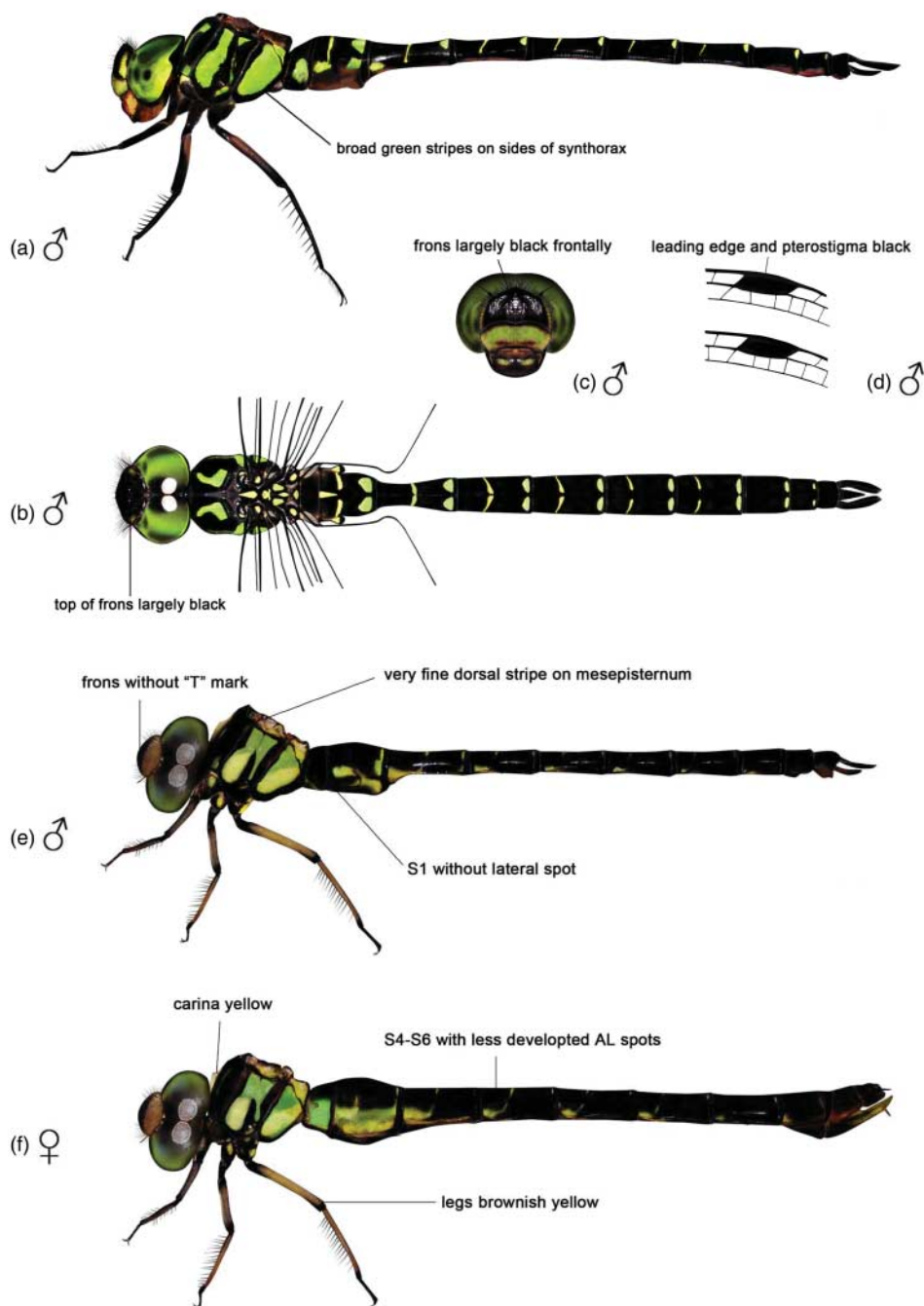


Figure 7. *Cephalaeschna obversa*, male from Guizhou (a–d) and *C. risi* from Zhejiang (male: e; female: f): (a) body in lateral view; (b) body in dorsal view; (c) head in frontal view; (d) leading edge of wings and pterostigma; (e–f) body in lateral view.

Prothorax. Mainly black. Synthorax black with green stripes (Figure 7a, b): dorsal carina entirely black; mesepisternum with comma-shaped dorsal stripes, and rounded spots below; mesepimeron with a broad stripe; metepisternum with a triangular shaped spot near the upper margin, and two linear stripes below; metepimeron largely green. Coxae pale brown, femur

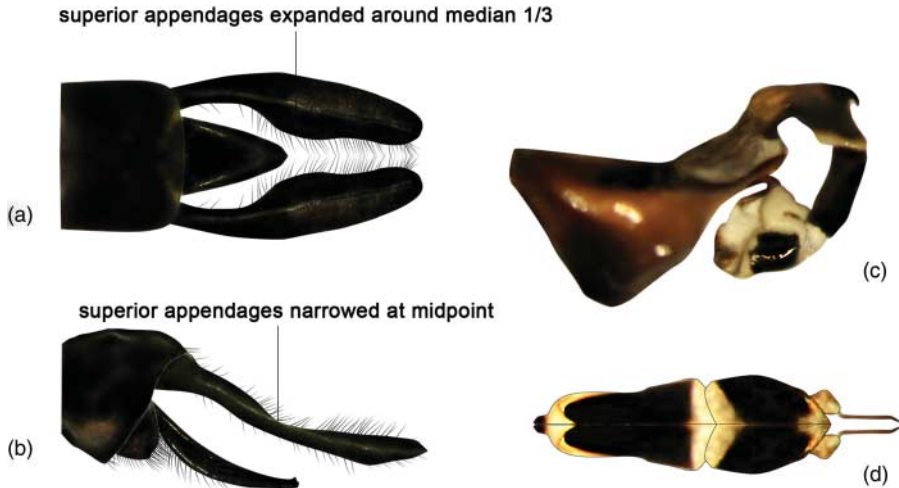


Figure 8. *Cephalaeschna obversa*, male from Guizhou: (a) appendages in dorsal view; (b) appendages in lateral view; (c) penis in lateral view; (d) penis in ventral view.

mainly black with the base reddish brown in median and hind legs. Tibiae, tarsi, and claws mainly black.

Wings. Hyaline. Triangle 4-celled in forewing pairs, 5-celled in hind wings, anal loop 6-celled, anal triangle 5- or 6-celled. Pterostigma brown (Figure 7d), 2.5 mm in length. Nodal index: 12: 19: 20: 12/15: 15: 14: 13.

Abdomen. Black with yellow markings (Figure 7a, b): S1 with large lateral spots; S2 with triangular AD spot, paired linear MD spots and paired semicircular PD spots. Laterally S2 with small AL spots above auricle, connecting with the MD spots, and semicircular PL spots which are connecting the PD spots, auricle black. S3–S7 with paired triangular MD spots which expand to the side, and the paired semicircular PD spots. S3 with triangular AL spots. S8 and S9 with paired small PD spots. S10 entirely black.

Appendages. Black. In lateral view, superior appendages slightly curved upwards, narrowed at midpoint (Figure 8b); in dorsal view, expanded especially around median 2/3, thence broad in apical 1/3, with a rather wavy inner margin and rounded apex (Figure 8a). Inferior appendage with apex not bifid, 3/5 length of superior appendages (Figure 8b). Penis shown in Figure 8c, d.

Measurements (mm)

Male (Hubei): total length 63.5; abdomen (including anal appendages) 49.5; hind wing 40.0; male (Guizhou): total length 63.5; abdomen (including anal appendages) 50.0; hind wing 41.0.

Variation in males

In a male specimen from Guizhou, the metepisternum has a triangular shaped spot near the upper margin, and two linear stripes below, and the male from Hubei possesses a linear stripe on the metepisternum, which is more developed than in the Guizhou male.

Distribution

China (Hubei, Sichuan and Guizhou).

Notes on biology

In Guizhou province, the species is only observed at dusk from mid July to September. Most of the individuals flew between 1900 h and 1920 h. Females and immatures were more easily encountered, usually circling near the stream as they foraged. Fully mature males appeared around 1900 h. They flew very swiftly across the stream, about 1.5–2.0 m above the water. No courtship or oviposition behavior was observed. It is unfortunate that the habitat, a narrow montane stream in the valley of Xiangzhigou, was polluted between winter of 2011 and spring of 2012, and no specimen was collected in the survey in August 2012. A single male was collected on a very sunny afternoon in a similar stream in Hubei province in mid September, when it was holding its territory over a small cliff with seepages.

Discussion

Both sexes of this species were simultaneously collected in Guizhou. The very broad face as well as the body maculation of female specimens match well with the description and illustrations of *Asahina* (1981a). The males possess very similar broad head and color pattern.

This is the smallest *Cephalaeschna* species hitherto found in China. Both sexes have an extremely broad frons, almost 2/3 the width of the head when viewed dorsally. This is also a good character to separate it from all the other known Chinese *Cephalaeschna*. From the structure of the frons and appendages, this species is not allied to any Chinese *Cephalaeschna* species but is very similar to *C. asahinai* Karube, 2011, recently described from central Vietnam. There is no clear difference in body color pattern or the shape of frons, but the superior appendages are different. In dorsal view, the superior appendages are almost parallel-sided in *C. asahinai* (Karube, 2011, figure 5); however, in *C. obversa* the superior appendages are bent and approaching apically. In lateral view, superior appendages slender in the basal half and expanded in the apical half in *C. asahinai* (Karube, 2011, figure 4), whereas in *C. obversa* the superior appendages are narrowed at the midpoint and expanded basally and apically. The well-developed thoracic and abdominal green stripes in *C. klotsi* and *C. needhami* are similar to those of *C. obversa* but both possess a narrower frons. Comparing the appendages in dorsal view, *C. obversa* differs from *C. klotsi* and *C. needhami* by having a wavier inner margin of the superior appendages. Photos of a living male from Guizhou province are shown in Figure 11e, f.

First description of the female *Cephalaeschna patrorum* Needham, 1930 (Figures 5f, g, 9e)

Material examined

One male, 1 female, Mt Wulingshan, Beijing City, China, Chao Wu leg., 20 August 2009.

Female

Head. Eyes dark blue in living specimen (Figure 5f). Labium brown. Labrum greenish yellow with the lower margin brown. Anteclypeus dark brown. Postclypeus greenish yellow with the lower margin brown and a pair of black depressions. Frons fundamentally greenish yellow, about

3/4 width of head, with a large brown spot, an inverted “V” mark in frontal view and a “T” mark dorsally. Upper margin of frons medially protruding upwards, with dense marginal setae. Occiput yellow, fringed with long setae at margin.

Prothorax. Mainly brown. Synthorax black with greenish yellow stripes (Figure 5f): dorsal carina entirely black; dorsal stripes on mesepisternum tapered anteriorly and bent outwards. Mesepimeron with a broad stripe; metepisternum with a triangular shaped spot near the upper margin; metepimeron with a broad stripe. Legs mainly reddish brown.

Wings. Hyaline, wing base tinted with smoky brown. Triangle 6-celled in forewing pairs, 5-celled in hind wings, anal loop 11- or 13-celled. Leading edge of wings and pterostigma dark brown (Figure 5g), 3.0 mm in length. Nodal index: 15: 22: 21: 16/19: 17: 17: 18.

Abdomen. Black with yellow markings (Figure 5f): S1 with small lateral spots; S2 with triangular AD spot, paired linear MD spots and paired semicircular PD spots. Laterally S2 with a broad stripe. S3–S7 with paired triangular MD spots which expand to the side, connecting to the linear AL spots and the paired PD spots. S8 with small paired AD spots, AL spots and PD spots. S9 with PD spots. S10 entirely black, sternite elongated to form a tapered prominence in lateral view (Figure 9e), and bifurcated into two branches which are slightly bent, the apices of the branches connecting. Superior appendages black, as long as S10. Ovipositor long, not beyond the apex of the superior appendages, brown in color (Figure 9e).

Measurements (mm)

Female: total length 69.0; abdomen (including anal appendages) 51.5; hind wing 46.5.

Distribution

China (Beijing, Shanxi, Henan, Shaanxi and Sichuan).

Notes on biology

The species is locally common in the mountains of northern Beijing, c. 700 m, where the emergence starts from mid June, and fully mature individuals can be seen in July but the largest population

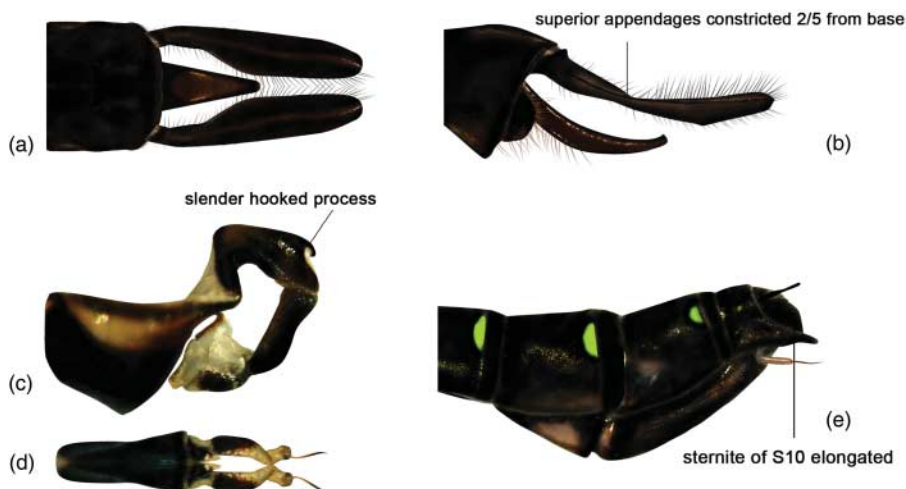


Figure 9. *Cephalaeschna patrorum*, male (a–d) and female (e): (a) appendages in dorsal view; (b) appendages in lateral view; (c) penis in lateral view; (d) penis in ventral view; (e) ovipositor.



Figure 10. *Cephalaeschna discolor* sp. nov, holotype male (a–b) and paratype female (c–d) and *C. solitaria* sp. nov, holotype male (e–f): (a) body in lateral view; (b) body in dorsal view; (c) body in lateral view; (d) body in oblique lateral view; (e) body in lateral view; (f) body in oblique lateral view.

appears from mid August to the beginning of September. In surveys in northern Beijing between 2007 and 2008, males were observed to be active after 1600 h on rocky montane streams, and most common between 1800 h and 1900 h. They hold their territory by constant hovering. They occupy both the fast flowing parts and the margins of the stream. Males fight for territory. Females oviposit from noon. They lay their eggs into mud near the shore or moss growing on the rocks both in the stream and in the shore. Larvae are also abundant in both riffles and at the edges of the streams.



Figure 11. *Cephalaeschna mattii* sp. nov, holotype male (a–b) and paratype female (c–d) and *C. obversa*, male from Guizhou (e–f): (a) body in lateral view; (b) body in dorsal view; (c) body in oblique lateral view; (d) body in dorsal view; (e) body in oblique lateral view; (f) body in dorsal view.

Discussion

C. patrorum is the only *Cephalaeschna* from China distributed in the Palearctic realm, and Beijing should form the northernmost border for the genus. Males of the species were well studied by Asahina (1981a), and are very similar to *C. solitaria* described above. The differences between males are discussed in Table 2. Females of the species are very different from all other known females of Chinese *Cephalaeschna* by virtue of the elongation of the sternite of S10 (Figure 9e), with its pointed apex. This structure is clearly seen in the females of *Gynacanthaeschna* and *Periaeschna*. But there is an additional spine on the apex of the elongation of S10 in *Periaeschna*.

Table 2. Comparison of characters between males of *C. solitaria* and *C. patrorum*.

Character	<i>C. solitaria</i>	<i>C. patrorum</i>
Stripe on mesepimeron	Clearly tapering to the base of wings	Not obviously tapering
S3-7	AL spot not connected to MD spots MD triangular and PD spots rounded	AL spot connected to MD spots MD and PD spots linear
Superior appendages in lateral view	Narrowed at midpoint	Narrowed 2/5 from base
Stem of penis	With a robust and not obviously hooked prominence	With a slim and strongly hooked process

which is absent in this female. Asahina (1981b) illustrated the female ovipositor of *Gynacanthaeschna sikkima*, which is very similar to this female. The apices of the two elongated branches of S10 are not connected in the female *Gynacanthaeschna sikkima* (Asahina 1981b, figure 72) as they are in *C. patrorum*, and the apex of the elongated branch is more pointed in *G. sikkima*.

Acknowledgements

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References

- Asahina, S. (1981a). A revision of the Chinese dragonflies of the genus *Cephalaeschna* and its allies. *Tombo*, 24(1–4), 2–12.
- Asahina, S. (1981b). A revision of the Himalayan dragonflies of the genus *Cephalaeschna* and its allies (Odonata, Aeshnidae) (Part 1). *Bulletin of the National Science Museum*, 7(1), 27–49.
- Asahina, S. (1982). Studies on the Chinese dragonflies of the genus *Cephalaeschna* and its allies in the collection of the Leiden Museum. *Tombo*, 25(1–4), 7–15.
- Karube, H. (2011). Two new species of the family Aeshnidae (Anisoptera) from Central Vietnam. *Tombo*, 53, 75–80.
- Walker, E. M. (1912). *The North American dragonflies of the genus Aeshna*. Biological Series 11. Toronto: University of Toronto.
- Wilson, K. D. P., & Xu, Z. (2008). Aeshnidae of Guangdong and Hong Kong (China), with the descriptions of three new *Planaeschna* species (Anisoptera). *Odonatologica*, 37(4), 329–360.
- Xu, Q. (2006). A new species of the genus *Cephalaeschna* (Odonata: Aeshnidae) from Fujian Province, China. *Entomotaxonomia*, 28(2), 94–94 (in Chinese with English abstract).